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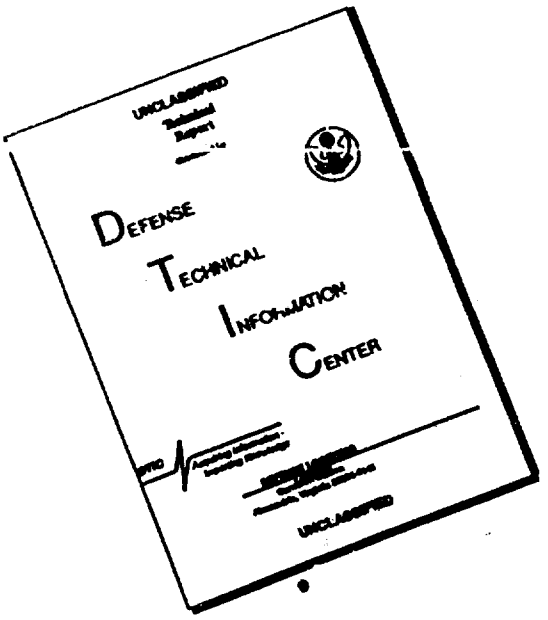

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DETERMINATION OF DROPLET SIZE IN OIL FOGS

by

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During recent years, fogs obtained by mechanical or thermic dispersion of petroleum, coal and other oils, have found wide application in the creation of protective fog screens, in the fight against malaria bearing mosquitoes (3), etc. In this connection there arose a need for a simple method, one that is suitable under field conditions, of determining the degree of dispersion of such fogs; furthermore, in view of the polydisperse nature of such fogs, it is not permissible to confine the determination to the average size of the droplets, it is also necessary to have an idea regarding the distribution of the droplet size. Therefore, of the numerous methods proposed for the measurement of dispersion of aerosols, the most suitable one in the given instance is the microscopic measurement of oil droplets deposited on a transparent support. For this purpose it is necessary to have a surface whereon the oil would produce as constant a rim angle* as possible, as only in such an event the precipitated droplets would have a regular shape of a lens and the ratio of the lens diameter to the diameter of the free droplet would remain constant. According to the data presented in the literature (1) it is customary to employ for this purpose glass slides coated with a layer of zinc stearate, however there are no data given in the literature regarding the method of preparation of the support material which would be suitable for the purpose indicated, nor is there any information regarding the magnitude of the rim angles produced on the support by various oils, etc. Hence, it was considered expedient to report the results of our experiments in this field.

Experiments conducted with neutral zinc stearate, $(ZnC_{18}H_{35}O_2)_2$, described in the literature (2) have demonstrated that this material is unsuitable. Neutral stearate when transferred in the molten state onto a glass slide inevitably crystallizes upon cooling and the oil droplets assume a completely irregular shape on the resulting crystalline film; and, of course, there is no possibility of obtaining a reproducible rim angle. Neutral stearate was prepared by us by precipitation from a hot solution of sodium stearate treated with an equivalent amount of zinc sulfate; this procedure results in the formation of a coarsely disperse, easily filterable precipitate and the filtrate gives an acid reaction towards phenolphthalein at the completion of precipitation. Additional experiments have shown that in order to obtain a satisfactory material it is necessary to use the zinc salt in an amount considerably less than the theoretical, so that the solution at all times would remain alkaline when tested with phenolphthalein. Under the latter conditions a highly dispersed, poorly filterable precipitate is obtained, which does not crystallize upon solidification, but solidifies into a horn-like, brittle amorphous mass. A small piece of this material is carefully melted on a specimen slide and is spread over it in a thin layer. On the surface prepared in the above manner oil droplets of any size form regularly shaped lenses having a rather constant rim angle. Stearates precipitated in an alkaline medium and which produce satisfactory results are the basic zinc stearates. They contain appreciably more zinc oxide than a product which is obtained in a neutral or weakly acidic medium and which is a pure neutral zinc stearate (ZnO content is equal to 12.5%).

* Translator's Note: Rim angle denotes the contact angle between the sessile droplet, referred to by the author as the "lens", and the supporting medium.

Preparation of Basic Zinc Stearate: 71 grams (~ 0.25 moles) of commercial stearic acid are saponified at 80-90°C with a solution of 10.8 grams (0.27 moles) of sodium hydroxide in 1.5 liters of water. The precipitate is obtained from the soap solution, at the same temperature, by the addition of a solution of 26 grams (0.18 equivalent weight) of zinc sulfate heptahydrate. The precipitate is filtered off in small portions, is washed on the filter with hot water, is dried at 110-120°C and is carefully melted at 170-190°C for the removal of last traces of water. ZnO content is 15.7%.

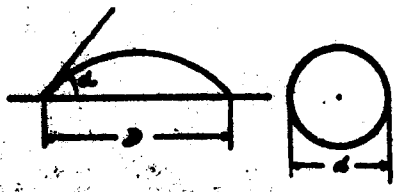

Fig. 1 Diameters of droplet (d) and of lens (D).

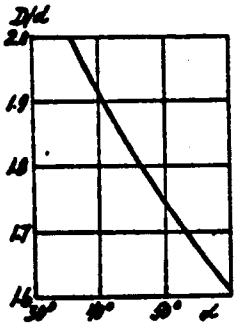

Fig. 2. Relationship Between the Ratio D/d and the Magnitude of the Rim Angle,

For the determination of the droplet diameter, d, from the lens diameter, D, (Fig. 1), in the event of sphericity of the latter, which is always the case in fogs suitable for practical applications, the following formula may be used:

$$\frac{D}{d} = \sqrt[3]{\frac{4\sin^3\alpha}{2 + \cos^3\alpha - 3\cos\alpha}}.$$

In Fig. 2 is shown a graph constructed on the basis of this formula.

Measurement of rim angles was done by us with the aid of a horizontally arranged microscope equipped with an eyepiece grid and the draw-tube had a circular scale. To the microscope stage was fastened a support made of a small piece of sheet metal bent at a right angle, so that the surface of the microscope slide resting on it was horizontal and parallel to the optical axis. Next, by turning the draw-tube the eye-piece lines were set sequentially: 1) parallel to the surface of the slide; 2) parallel to the tangent at the left-hand base of the lens; 3) the same, at the right-hand base and the corresponding angles of rotation were read off with a precision of ~ 0.5°. Since the magnitudes of the left-hand and right-hand rim angles were practically coincidental, in further work only the angle between positions (2) and (3), equal to 2α, was measured.

Discrepancy between the values of α obtained for various lenses did not exceed 1-2°, hence it was adequate for each oil to take the average of three measurements. The size of the angle is practically independent of the size of the lenses, and since the measurements in the case of large lenses are more precise, lenses having diameters of 1-2 mm and objective No. 2 were used.

Since a highly refined petroleum oil ("Superiya") and Ufimskii gas oil containing 50% aromatics give almost identical values for α, it appeared to us to be entirely unnecessary to carry out detailed analyses of the oils. For the majority of oils the ratio D/d is equal to 1.8. The values of D/d presented in

the third line of Table 1 refer to droplets having diameters of ~ 2.5 mm (diameter of the lens 5 mm) and they were obtained by direct measurement of the lens diameter and volume of the drop. It is evident from Table 1 that even in the case of such large drops the departure from sphericity, apparent from the difference between the calculated and measured values of D/d, is comparatively small.

Table 1

		Superlya	Transformer Oil	Groznen-skii Paraffin Filtrate	Machine Oil	Ufimskii Gas Oil	Diesel Fuel	Anthracene Oil	Linseed Oil	Water
α		46.5	46.0	45.5	48.5	45.0	40.5	58.8	54.5	90
D/d	Calculated	1.80	1.81	1.82	1.77	1.83	1.91	1.63	1.68	1.26
	Measured	1.85	-	-	-	-	2.00	-	-	-

It is of interest that basic zinc stearate is simultaneously lyophobic and lyophilic substance.

Conclusions

Neutral zinc stearate described in the literature is not suitable as a "support" for the determination of dispersion of oil fogs. Satisfactory results are obtained only when basic zinc stearates, formed by precipitation in an alkaline medium, are employed.

Prof. Ya. V. Samoilov
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